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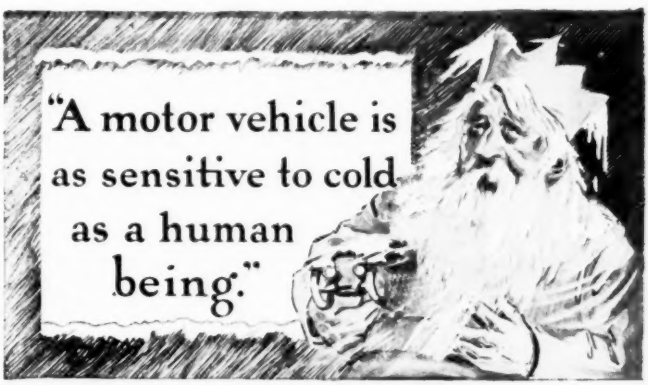


Care of the Motor Car in Winter

THE care of the motor car in winter is in all probability one of the most perplexing problems confronting the average motorist today. To the man whose knowledge of his car is limited to certain rule-of-thumb principles of operation, cold weather driving appears as a horrible nightmare of endless batteries exhausted in starting, perhaps back-breaking cranking, frozen radiators, worn gears and bearings and engine troubles due to poor lubrication.

To overcome these objections, which are in no way exaggerated, it has been the common aim of automotive engineers to design the modern motor car to be efficient and capable of ready operation whatever the atmospheric temperature. Certain parts of the car, such as the carburetor, necessarily have had to be made capable of accurate adjustment according to the operating temperature. But on the whole the automobile of today is of so-called standardized construction insofar as adjustment to meet weather conditions is concerned. Efficient results, however, can not be attained simply for this reason. Attention must also be given to operating principles as involved in the handling of the fuel, lubrication of the engine, the use of anti-freezing solutions and radiator covers, thermostats or shutters to maintain the cooling water at the proper tem-

perature. Therefore, cold weather operation of the motor car can well be viewed from the following five distinct angles:

1. The fuel and its manner of usage.
2. Lubrication of the Engine.
3. Lubrication of Transmission, Differential and Chassis.
4. The Cooling System.
5. Care of the Battery.

Careless operation and lack of attention to these details may give rise to any number of discomforting and expensive results, as shown in the table opposite page 1.

Motor Car Fuel

Due to the magnitude of the demand of the motoring public which is straining our national petroleum resources almost to the breaking point, refinery practices have been revolutionized. It has been found possible to break down certain of the heavier distillates into gasoline by means of what is known as the "cracking" process, but even with these it has been impossible to keep up with the demands and it has become necessary to include considerably more of the so-called heavier ends than formerly. As a result of such methods of refining, motor gasoline today has a higher final boiling point than heretofore. In other words it is heavier though capable of developing more power per gallon.

In the summer, or in winter when the motor is running under warm conditions, there is no difficulty experienced with modern gasoline but under extremely cold engine conditions, especially in starting, the amount of gasoline which will vaporize without external heat is considerably smaller than in warm weather or when the engine is hot. As carburetors are adjusted for the heated condition, in order to obtain the proper mixture of vapor and air it is customary to use the choke, which cuts down the amount of air delivered to the mixture on starting.

Effects of Priming and Choking

To burn any gasoline efficiently in the modern automobile it must be vaporized to an extent, which would require that the mixture of gasoline and air be heated well above 100° F. Unless this temperature is at least 200° F., the mixture will be excessively wet, and crankcase dilution and carbon formation, etc., may be a direct result. Even with winter grades of gasoline it is evident that it would be frequently impossible to heat to this extent when starting in very cold weather, due to low air temperature. Therefore "priming," or the addition of an excessive amount of gasoline to the cylinders through the pet cocks, or "choking" of the carburetor would have to be resorted to. Naturally in a cold engine less of the excess gasoline used will vaporize than under usual running temperatures. Therefore considerably more of the heavy ends will remain in liquid state to leak past the piston rings, wash the film of lubricating oil from the cylinder walls, and work into the crankcase, where dilution of the lubricating oil will result. If this is allowed to continue, other detrimental features will be: (1) a tendency of the engine to overheat, and (2) an ultimate excessive formation of carbon.

It is evident that continued use of the choke to produce a relatively uniform flow of rich mixture to the engine, especially when warming up, would bring about the same objectionable results; therefore in using, the choke should be pulled all the way back until one or two explosions have taken place. Then it should be pushed in and the engine kept running by working the throttle back and forth until warming up is completed. Unfortunately, priming and use of the choke are necessary evils in practically every instance of starting where the garage is unheated or the car is stored in the usual manner with perhaps only a robe thrown over the radiator. Yet the motorist should resort to them as little as possible, if he has the welfare of his car at heart, and the engine should never be run at more than moderate speed until the lubricating oil has had time to be worked up onto the cylinder walls and replace that which has been washed off by the liquid fuel referred to above.

It does not require very much gasoline mixed with motor lubricating oil to reduce the viscosity (or thin down) the latter to such an extent that it is no longer able to lubricate the engine properly. Addition of fresh oil will overcome this to some extent, though never to an absolutely satisfactory degree. The only positive remedy is to drain the crankcase, as is fully discussed in a later paragraph.

A very popular method of facilitating starting in certain localities where cold is extreme is

to wring out a cloth in hot water and wrap it round the carburetor. In fact this procedure may become an absolute necessity in event of water having gained access to, and frozen in, the float chamber, thereby clogging the spray nozzle.

Normally incomplete vaporization will be liable to occur only during the period of warming up if proper covering is fitted to the radiator

Fig. 1.—Example of the manner in which a perfectly good valve may be burned on account of imperfect seating due to carbon on the valve seat, or improper adjustment.

to keep the water at such a temperature (i.e. in the neighborhood of 150° F.) that the engine will not run too cool. However, many motorists operate continually with an unprotected radiator, unless the temperature drops to zero or below, with the idea that the engine heat will still counteract the lower water temperature. In the neighborhood of 25° to 35° F. this might be true, but below these temperatures the engine will run too cool, vaporization of fuel will not be complete, and excessive dilution of crankcase oil will occur, as explained above, during the entire period of operation. Therefore, it is safest to use the radiator cover continually throughout cold weather. This is a mechanical device to cut down the frontal area of the radiator when the car is in operation, and cover the former entirely when the car is idle. As a general rule a radiator cover does not involve any chance of the engine overheating, if it is kept open from one half to its full area during the period the car is operated. Under such conditions enough of the frontal area of the radiator will remain covered to prevent the engine from running cold, and yet it will not overheat.

Water in the Gasoline

Water in the gasoline should be carefully guarded against in cold weather operation, due to the possibility of its giving trouble by freezing in the gasoline pipe, carburetor, or even the bottom of the storage tank. Should a drop of water come in contact with a fine mesh strainer located in the fuel line it may entirely cover the mesh with a film. Should this film freeze, which might happen even when immersed in the fuel, a stoppage in the flow of gasoline would occur, perhaps even to the extent of shutting off the entire supply. To locate the source of such a trouble while out on the road might be a difficult matter, as the frozen film covering the screen may not be readily apparent to the eye, and considerable labor and time would no doubt be involved before the cause of the stoppage in the fuel line could be ascertained. Even if such a film of water did not freeze there would still be the possible objectionable feature of misfiring.

In the motor car storage tank, water could gain easy access were the filling cap left loose, the tank filled in the rain, or certain of the seams leaking. Another prevalent cause of water accumulation in the gasoline tank is condensation of the moisture in the air. This is especially liable to occur if the car is stored in a warm garage, and then driven out under excessively cold atmospheric temperatures. In the same manner a certain amount of water will be condensed in the crankcase.

Water in the carburetor is indicated by misfiring. In this event the carburetor drain should be opened to remove any slugs of water that may be present. It would also be advisable for the motorist to thoroughly inspect his tank for the presence of water at the earliest opportunity, and to drain the gasoline from the system and strain it.

Carburetor Adjustment

In connection with winter operation of the motor car, carburetor adjustment plays a most important part. In fact it is one of the most essential adjustments on the engine, and there is a marked difference between winter and sum-

mer settings. While the effort should always be made to run with as lean a mixture as possible, yet in cold weather the normal richness of the gas must be markedly increased. Were this not done, starting difficulties would be great and it would be necessary to use the choke almost continually, with the detrimental results noted above. Hence the modern carburetor is built for suitable adjustment in order to vary the percentage of gas and air, as well as the temperature of the latter, that go to make up the fuel mixture. Such adjustment should always be made by an expert. If the average driver attempts it, in all probability he will run into all sorts of difficulties.

Improper adjustment of a carburetor may give rise to:

1. An excessive consumption of fuel,
2. Loss of power, and
3. A decidedly uneven running of the engine.

Lubrication of the Engine

Water Accumulation

In the previous paragraphs the matter of crankcase dilution has been discussed, and regarded as a function of the state of vaporization of the fuel. In this connection there is another detrimental feature that may frequently occur in cold weather operation: water accumulation in the crankcase, and the possibility of freezing and injury to the oil pump when the engine stands idle without external heating. Some of this water is accounted for by the condensation of the steam (or water vapor) that is one of the by-products of combustion when the gaseous mixture of gasoline vapor and air is fired. Under normal weather conditions, with a sufficiently warm engine this steam will be emitted along with the other exhaust gases. In the winter, however, particularly on starting or warming up a cold engine, or in event of the cooling water temperature being too low, part or all of this steam will be condensed through contact with the cold cylinder head surfaces. The resultant water will tend to leak past the piston rings and drain down into the crankcase to settle in a layer below the oil and usually surrounding the oil pump. If this accumulation becomes extensive, and if the car is stored or left standing for any length of time in an atmospheric temperature much below 32° F. (freezing) in all probability the engine base wi cool sufficiently to enable this water to freeze This would render the oil pump screen inopera tive or cause the pump to break, thus prevent ing oil circulation, which would result in burne out bearings and scored cylinders and pistons In addition expansion and contraction whic

Fig. 2.—The stem and under side of the valve shown in Fig. 1. N manner in which the seat or face of the valve has been burned awa

will accompany such freezing (and the subs quent melting) may also possibly cause a fra ture in the crankcase bottom, which will i volve considerable expense for welding and r placement. On the other hand, if this wat did not freeze, its presence would probab result in quite as serious a consequence su as scored cylinders or burned bearings, account of lack of, or imperfect, lubricati Even a small quantity of water may in so particular cases cause quite an emulsion, wi water in excessive amount might, in extre cases, entirely supplant the oil in the lubricat system.

Draining the Crankcase

The best way to minimize water accumu tion in the crankcase, as well as dilution

lubricating oil in cold weather, is to make it a strict rule to change the oil and drain the case every 400 to 500 miles, or once a week if short trips are made. It is evident that water accumulation and dilution can not be entirely guarded against, but frequent change to fresh oil will certainly minimize the possible detrimental effects. It is usually good practice to wash the crankcase with a quart or two of warm light motor oil after draining, to remove sediment deposits from corners and other crevices. The use of kerosene as an engine wash has been practically discarded due to the possibility of part of the kerosene remaining in the crankcase to dilute the fresh motor oil installed. Very frequently the crankcase drain plugs are not located so that all the washing oil can be readily and completely drained, and for this reason it is generally advisable to use a light lubricating oil for flushing, even though the expense may be slightly greater. Never run the engine by its own power in such cases, but turn it by hand or with the self-starter. Then drain off the wash oil. After draining the oil, which can be used, if not too dirty, for certain chassis lubrication, or to thin out the transmission lubricant, the engine can be given its usual charge of fresh oil. It will be always advisable to drain the crankcase of used oil while the engine is hot, inasmuch as considerable of the sediment and other accumulations of foreign matter will be drained out, and it may not then be necessary to bother with a light oil wash each time.

In event of breaking in a new engine, or one wherein the cylinders have been rebored, it will be generally advisable to drain and flush the crankcase after each 200 to 300 miles for the first 1000 miles of running, refilling the crankcase each time with clean motor oil in the usual manner. After these preliminary changes of oil the usual frequency of approximately every 500 miles can be followed out. There is a very good practical reason for these first changes of oil and cleaning of the crankcase. In relatively every new engine, or instance of rebored cylinders, there will be present a certain amount of the metallic surfaces which will have a tendency to wear or polish off in the form of minute particles and mix with the lubricating oil during the period over which the pistons and cylinders are worked into a smooth "running fit". It is perfectly evident that these particles will act as abrasives to cause rapid and abnormal wear of the engine bearings, cylinders, piston rings and other parts served by the lubricating oil, unless they are removed from the system. Naturally the only effective way to remove them is to thoroughly drain and wash out the crankcase after the engine has operated

Fig. 3.—Example of piston carbonization probably due to excessive oil having been used. Sufficient carbon is present to have caused "knocking", though the piston itself is in perfect condition.

a sufficient length of time to insure that practically all of such free metal has been taken up by the lubricating oil.

Crankcase Dilution

There is considerable difference of opinion as to the actual harmful effects that may result from crankcase dilution. This subject has been extensively discussed in the technical press and in various advertising bulletins so frequently from an alarmist point of view that it has come to be regarded by the average motorist as the veritable "bugaboo" of motor car operation. Notwithstanding that it is generally agreed that crankcase dilution does occur at practically all times, and especially rapidly in winter operation, it is doubtful whether it is worthy of all the attention it has received. Certainly it has been treated in a rather biased manner and

many statements have been made that are chiefly suppositions.

From a lubrication viewpoint there is relatively little danger of bearings actually burning out purely because the lubricant is reduced in viscosity by ordinary fuel dilution. A lighter lubricant will splash more freely and there will be greater possibility of pumping occurring, which may result in excess carbonization and the piston seal becoming impaired, with consequent loss in compression.

In the average running of the car, crankcase dilution apparently reaches an equilibrium point after a sufficient length of time, notwithstanding the entry of a certain amount of the lighter diluents whenever the choke is used or priming resorted to. However, if the dilution for any reason, as by excessive use of the choke, becomes abnormal and the diluent is by far the major part of the lubricating mixture, a condition may arise, as for instance in the sudden application of the load, wherein the lighter or diluent portions will be rapidly evaporated from the film on the cylinder walls because of rapid heating of the cylinders. In such a case, the lubricating film may be reduced sufficiently in thickness so that scored cylinders will certainly be a possibility.

Experiments have shown that while the state of equilibrium between the lubricating oil and the lighter fuel portions will vary with the nature of the constituents, it will balance itself of its own accord if sufficient time is allowed. That is, if an equilibrium condition of 20% diluent was normal for the case in question, if 40% diluent were started with in the crankcase the lubricating mixture would tend to return to its state of equilibrium.

Insufficient Lubrication

If at any time the oil level in the crankcase becomes too low (by reason of lack of attention to the oil gauge, or if it is inoperative) and the engine begins to pound and overheat abnormally, it should be stopped as soon as possible and allowed to cool. An experienced operator will detect the loss of power and discern the cause before damage is done. Fresh oil should then be added to bring the level up to normal. It is possible that damage may have occurred due to the necessity of running the engine under these conditions for any length of time. It is therefore advisable to have a thorough inspection made, if possible, before the car is again driven, to make sure that cylinders or piston rings have not been materially damaged, or bearings scored or burned.

Selection of the Lubricant

In cold weather operation of motor vehicles the efficiency of the engine from a lubricating viewpoint will be largely dependent upon the operating temperature and viscosity of the motor oil used. In turn the viscosity is essentially a function of the temperature. Hence it is evident that under colder atmospheric conditions the viscosity of a lubricant will increase, resulting in a lower degree of fluidity and involving greater internal fluid friction. Naturally this will cause a reduction in lubricating efficiency and necessitate a greater consumption of power to bring the car to the desired speeds, or until the temperature of the oil has been raised sufficiently to cause a proper decrease in viscosity. If the normal viscosity of the oil at 100° F. be relatively high it is perfectly clear that under exceedingly low temperatures this oil might become so sluggish as to be relatively difficult to pump. It is for this reason that lighter (lower viscosity) motor oils are used in the winter than in the summer. Another reason is that a heavier lubricant congeals far more rapidly when subject to cold than a lighter oil. In the refining of motor oils it is possible to vary the pour test or temperature of congealment to some extent. Naturally the lower this temperature, or in other words the lower the pour test the more suitable and dependable will the oil be for cold weather operation, other factors being equal. In view of this, the motorist should endeavor to obtain as low a pour test oil as possible for winter usage.

In general winter operation, the viscosity of the motor lubricant should be reduced so as to give approximately the same lubricating efficiency as in warm weather. For example, were a heavy oil recommended for summer service in a particular engine, the use of a medium viscosity oil in the winter would generally be proper.

It can be appreciated that too viscous a lubricant might be the source of all manner of engine troubles such as burned bearings, scored cylinders or seizing of certain parts, due

being too viscous to be properly transmitted to these parts. The claim may be advanced that the more or less common condition of crankcase dilution will soon cause the thinning down of such a lubricant to enable it to flow properly. Crankcase dilution, however, is an extensive variable as has been already discussed, and it should never be depended upon to perform any such function. In fact even with proper use of the priming cup and choke it would be a very doubtful agent to rely upon for viscosity reduction, and much damage could be done before dilution to the extent required would take place while operating with a lubricant of too high a viscosity.

If, in the opinion of the operator, the atmospheric temperature is so low as to render an otherwise suitable motor oil temporarily so sluggish as to be incapable of proper lubrication, he should warm up his cold engine very slowly, until the heat generated has reduced the viscosity of the oil sufficiently to enable it to be properly pumped. Otherwise bearing troubles will be sure to arise due to lack of lubrication.

The amount of dilution necessary will depend to a large extent upon the severity of the weather. It must be realized that there is normally little heat generated by such gearing. Hence if an average transmission lubricant with a pour test of from 15° to 25° F. were cooled to the neighborhood of zero, it would congeal to such an extent that the gears would probably simply cut a channel in it, and insufficient lubrication would be a certainty. The excessive wear that would result from dry gear teeth would not necessarily generate enough heat to thin out the lubricant in the base of the case sufficiently to renew proper lubrication.

In general the addition of sufficient motor oil in an approximate ratio of two parts of gear lubricant to one part of motor oil, will render the gear lubricant of the proper consistency. When this lubricant is thoroughly mixed in the transmission and rear axle there will normally be sufficient flow in cold weather to insure lubrication of all gears and bearings, and it will have the added advantage of reducing the power necessary for starting in cold weather.

Fig. 4.—Illustration showing the extent to which lack of lubrication may damage a wrist pin and its bearings. Note that portions of the bearings are actually welded to the wrist pin itself. It was necessary to break the piston to remove the pin.

Lubrication of Transmission, Differential and Chassis

Differential and Transmission

The lubricant in the differential and transmission gear cases which serves the gears and rear axles will, in general, give better service in the winter time if it is thinned out to a certain extent with motor oil. For this purpose the oil that is used to flush out the crankcase may be used if it is not too dirty.

In the selection of the transmission lubricant there is far less latitude possible than in the selection of motor oils for winter service. Usually the same grade will be advisable and most economical for all-year-round service, if it is thinned out properly in extremely cold weather as explained above. The base lubricant itself should preferably be a medium bodied gear oil having a viscosity of about 200″ Saybolt at 210° F. Semi-solid lubricants of the nature of high soap-content greases are not recommended

for this service. In cases where an oil would leak out from the gear case, or through the axle bearings to drip onto the brake bands and ultimately render them ineffective, a semi-solid pure mineral lubricant will be found most suitable. Grease as we know it today, with its high soap content and its relatively low percentage of mineral oil, is not generally considered the proper lubricant to use in transmission and differential housings of rear axles. Modern practice is to build such parts oil tight. It is readily seen that while a soap-grease lubricant might seem perfectly satisfactory in hot weather, though probably entailing higher starting and running torques due to its extreme body, on the other hand under even moderately low temperature conditions it would become so stiff as to simply "channel" when the gears were revolved, to the ultimate ruination of gear teeth and probably axle bearings. In other words, to insure efficient lubrication of such parts the lubricant must be capable of thorough distribution to lubricate properly all the moving parts at all times.

Chassis and other Parts

Under this category can be included lubrication of the chassis, steering mechanism, universal joints, etc. Normally of all moving parts on a vehicle, the chassis and its appurtenances receive the least attention and are expected to run for a long time without much consideration. The wear that is bound to occur in such a case is naturally great, and infinitely more important from a safety viewpoint. Failures of gearing or motor bearings would normally not result in more personal inconvenience than a severe jolting, before the car could be brought to a stop. However, failure of the steering gear, or shearing of an axle and the loss of a wheel, might very easily result in fatalities.

In cold weather operation chassis parts require more attention than in the summer time. Grease and oil cups are exposed and their contents may easily become so congealed that all lubrication will cease for days at a time. No protective measures are available, hence the only recourse of the motorist is to make his inspections more frequently and with greater care. It will be to his advantage as well to use a lighter grade of cup grease for all grease cups and the same grade of oil as in his engine for oil cups.

The Cooling System

Anti-Freezing Solutions

In order to protect the cooling system against freezing and guard against a leaky radiator cracked cylinder blocks or frozen water pump the water must be mixed with a certain amount of alcohol, alcohol and glycerine, or dissolved salts; or else a light grade of mineral oil can be substituted for such mixtures. In using water solutions the purpose, of course, is to lower the freezing point of the mixture below the probable lowest atmospheric temperature likely to be encountered. Whatever the nature of the non-freezing compound, an ideal solution should have certain definite properties; in other words:

1. The ingredients used should be easily obtainable in operating localities.
2. There should be no possibility of freezing.
3. It should not be injurious to either the engine or the radiator through corrosion or electrolytic action.
4. It should not lose its non-freezing and non-congealing properties after continued use.
5. In the case of water solutions the compound used should not materially change the boiling point of pure water.
6. There should be the least possible fire hazard.
7. The boiling point of the solution should not be too high above that of water.
8. It should have as constant a viscosity as possible through the entire temperature range it will be subjected to, and it should remain perfectly fluid and not tend to stop up any small openings in the system.
9. It should be able to conduct heat away as rapidly as possible.

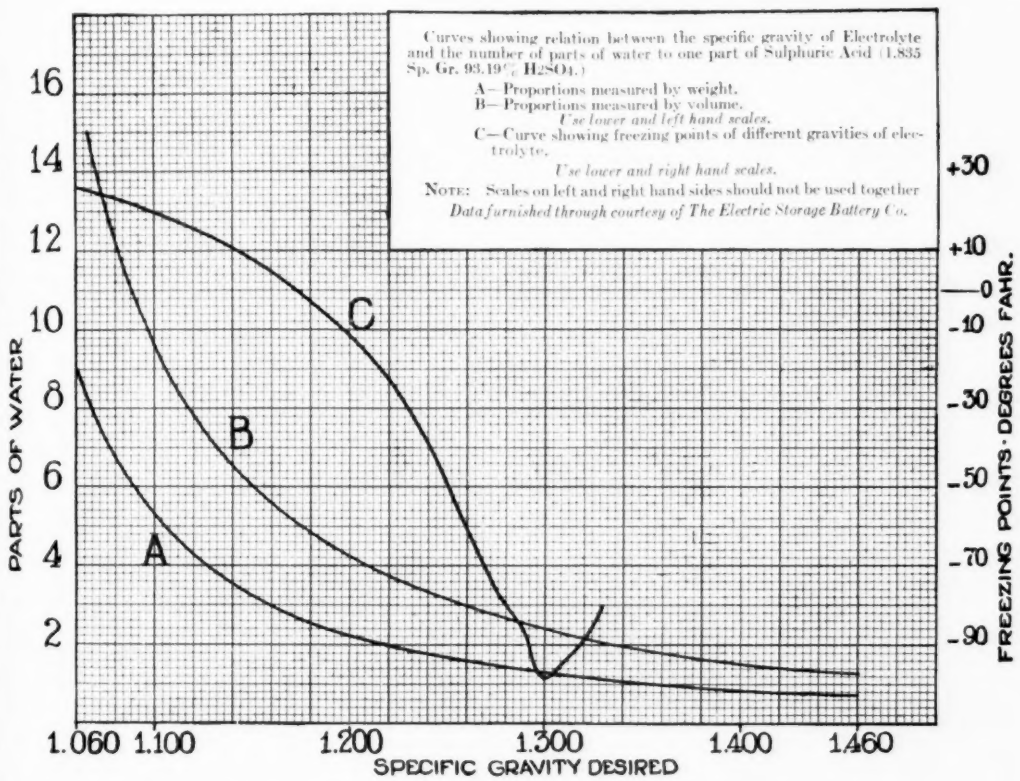
Alcohol-water anti-freezing mixtures are probably the most commonly used by the motorist today, owing to the fact that alcohol is easily obtainable at reasonable cost. The grade used may be either denatured or wood alcohol. Alcohol solutions do not have a greater tendency to corrode the metallic parts of the system than water alone. On the other hand wood alcohol often will contain free acetic acid. It is advisable as a result not to use wood alcohol unless it is definitely known to be acid free. The amount of alcohol used will affect the freezing point of the mixture, as is shown in the following table:

TABLE I
Alcohol Anti-Freezing Mixture*

% Volume of Denatured Alcohol	*Specific Gravity of Solution at 60° F.*	*Freezing Point of Solution*
10	0.988	27° above Zero Fahr.
20	0.978	19° above Zero Fahr.
30	0.968	10° above Zero Fahr.
40	0.957	2° below Zero Fahr.
50	0.943	18° below Zero Fahr.

There may be some slight variation from the above figures for the specific gravity and freezing point according to the purity and grade of alcohol used.

In the use of alcohol as outlined above it must be remembered that it will evaporate far more rapidly than water. Hence a certain amount must be added as make-up from time to time to keep the concentration of the mixture as desired. For this reason it is well to test the specific gravity of the alcohol mixture regularly with a hydrometer calibrated for temperature correction, and check the reading with the above table. Alcohol, however, lowers the boiling point of water to quite an extent if used in large amounts. Consequently it may frequently occur that on a comparatively warm day when the engine is "idled" the solution will boil readily and abnormal evaporation will take place, thus raising the freezing point of the remaining mixture. To overcome this tendency it is often preferred to use a mixture of equal parts of alcohol and glycerine as the anti-freeze component in the cooling water. The high price of glycerine, however, will prevent many people from using it for this purpose.



A typical example of the use of this table, assuming that the lowest temperature anticipated is 19° above zero Fahr., is as follows: †"If the radiator holds 3.5 gallons, 20% of this must be alcohol and the remaining 80% water. 20% of 3.5 gallons is 0.7 gal. or a little more than 5.5 pints which is the quantity required. This should be added to enough water to make 3.5 gallons; that is, the water used will be 3.5 gallons less 0.7 gal. or 2.8 gallons, a little more than 11 quarts."

Glycerine, contrary to alcohol, raises the boiling point of water, and thus it neutralizes to

*The above table has been compiled from data developed by the Bureau of Standards.

†"Anti-Freezing Solutions," Jour. of The Society of Automotive Engineers, Nov., 1921.

some extent the effects of alcohol in this regard. Glycerine, however, is somewhat more injurious to the rubber connections which are used between the radiator and engine. A glycerine mixture does not evaporate as readily as an alcohol mixture, so the cost and amount of ingredients used in renewing the solution will not be as great. Table II gives the essential data for such a solution:

TABLE II

Glycerine—Alcohol Anti-Freezing Mixture*

% *Denatured Alcohol and Glycerine (Equal Parts)*	% *Water*	*Freezing Point of Solution*
10	90	25° above Zero Fahr.
20	80	18° above Zero Fahr.
30	70	9° above Zero Fahr.
40	60	8° below Zero Fahr.
50	50	26° below Zero Fahr.

Glycerine-water is another anti-freezing mixture that is often recommended. Table III gives the approximate freezing point of glycerine-water mixtures of various proportions. It can be appreciated that the freezing point will vary considerably with the gravity of the glycerine used.

TABLE III

Glycerine—Water Anti-Freezing Mixture

% *Glycerine*	% *Water*	*Freezing Point of Solution*
10	90	20° above 0° F.
20	80	10° above 0° F.
30	70	0° F.
40	60	10° below 0° F.
50	50	20° below 0° F.

Salt Solutions

Salt solutions, made chiefly by dissolving common table salt or more frequently calcium chloride in water, are sometimes used as anti-freezing mixtures in case alcohol or glycerine is unobtainable. The principal advantage of such compounds is that they are non-volatile. On the other hand the use of such chemicals is never advisable except in an emergency, due to the possibility of troublesome consequences on account of these chlorides attacking the metallic parts of the system, especially if there is any aluminum in the cooling system.

Mineral Oil as a Cooling Medium

Kerosene or light lubricating oil may also be used as a cooling liquid. Opinion differs as to their value for this purpose. There are many instances of motor vehicles where kerosene or winter black oil has been successfully substituted for a water solution in winter service. As yet there is not enough data to warrant definite conclusions as to their efficiency. Kerosene has a higher boiling point and a lower freezing point than water. Due to the fact that it has a comparatively high boiling point and a low specific heat it is advantageous to use in cold weather, because it enables the engine to heat up more rapidly upon starting. Mineral oils in general have an injurious effect on rubber connections.

In tractor operation preliminary tests have indicated the use of oil as a cooling solution to be very satisfactory where kerosene is used as fuel. Probably the most satisfactory viscosity of an oil for this service would be in the neighborhood of 100″ Saybolt at 100° F. It should be a product from such a crude, or so refined as to prevent possibility of crystallization of any of its constituents, such as paraffine, in the colder parts of the system were the engine stopped for any length of time. In such event subsequent uneven heating of the metallic surfaces would be almost sure to occur.

Freezing

If the water or cooling solution should freeze at any time, either through carelessness or sudden abnormal temperature drop, never try to thaw it out by running the engine. If possible the garage should be heated or the car should be towed to a warm place. If this is impracticable it may be possible to thaw out the system by applying towels or rags wrung out in boiling water to as much of the cooling system as possible, though observing every care that no water drips upon any part of the ignition system.

Water Temperature Control

While it is most essential that the water in the cooling system be kept from freezing, it is also very important that its temperature be controlled at least to some extent in order to enable the engine to operate at its best. This subject has been briefly touched upon heretofore in connection with priming and choking and the matter of thorough vaporization of the fuel, when radiator covers were also discussed. These latter have three distinct advantages that should be remembered: i.e. they keep the engine and radiator warm; they make starting

*The above table has been compiled from data developed by the Bureau of Standards.

easier and save the storage battery to a marked extent.

In order to aid in regulating the temperature of the cooling water, increase the thermal efficiency and reduce carbon deposits, the thermostat is a valuable adjunct in a cooling system. By this device free circulation of the cooling water is blocked from the cylinder cooling jackets until the temperature of the walls has reached the desired temperature for which the thermostat is set. Thus the walls and the cylinder head can be kept at a sufficiently high temperature to aid in the complete vaporization and burning of the fuel. In addition carbon deposits from any excess lubricating oil will be reduced, due to the amount of oil that it is necessary to burn being decreased. Crankcase dilution is also materially forestalled, as already discussed. Automatic radiator shutters are also used to serve this same purpose.

These latter have the added advantage in maintaining a relatively uniform temperature in the air passing to the carburetor. Using a thermostatic control it is obvious that in certain instances the water passage might be so reduced that the air passing under the hood to the carburetor would take up relatively little heat, hence the temperature of the mixture might suffer a decided drop.

It is difficult to foretell to what extent the temperature under the hood and the operating temperature of the engine will vary over all year-round running. It is perfectly natural to assume that if due precaution is taken to maintain the engine at its proper operating temperatures there will be less necessity for changing the grade of oil used in the crankcase.

Care of the Storage Battery *

The essential point involved in the care of the storage battery in cold weather operation is to maintain the battery solution at such a concentration that there will be as little danger as possible of its freezing. The freezing point will depend entirely upon the strength; i.e., having given a solution the specific gravity of which is 1.250, there will be no danger of its freezing unless the temperature drops to the neighborhood of 62° below 0° F., which is of course very improbable. On the other hand, a solution having a specific gravity of 1.150 will have a freezing point in the neighborhood of 5° above 0° F. It is therefore evident that the battery should never be allowed to become run down or completely discharged, inasmuch as in this state there will be greater danger of freezing due to the reduced concentration of the liquid. However, there is the advantage that the solution is slushy when the battery is under these conditions, and it will not become hard until the temperature drops even below the figure indicated.

Consequently it is advisable to test the concentration of the battery solution by means of a hydrometer at least once every month. In this connection the following data will be of value:

a. Readings between 1.225 and 1.150 indicate that the battery is about half charged. If the car is equipped with an electric starter, lamps and starter should be used sparingly until the readings come up to the specific gravity as recommended by battery manufacturers, probably somewhere between 1.250 and 1.325. If there is no charging generator on the car, it is time to give the battery a bench charge.

b. Readings less than 1.150 indicate discharge; in this case the battery should be given a bench charge. Oftentimes this discharged condition may be due to need for adjustment in the system.

c. If the reading of one cell differs from the others by 50 points or more, it indicates loss of electrolyte, wrongful addition of electrolyte or internal trouble in the battery.

When it is necessary, as indicated by the reading of the hydrometer, to adjust the strength of the solution, the following procedure should be carried out:

1. Be sure the battery is completely charged.

2. Have ready some electrolyte (pure sulphuric acid diluted with pure water) with a strength of 1.285.

3. Dump the solution out of the cells and at once fill the cells with the prepared electrolyte. Do not allow the battery to remain empty.

4. Charge for an hour at the proper charging rate for the battery in question.

5. If the hydrometer reading is still below or above the point as recommended by the battery manufacturer, adjust again until it falls between the limits recommended.

* This information has been obtained in part by courtesy of The Electric Storage Battery Co.

At all times the plates should be properly covered with the battery solution. Due to the evaporation of the water constituent it will be necessary to add pure distilled water to maintain this condition. However, the rate of evaporation will be less in winter than in summer. When it is necessary to add water in cold weather it should be done just before the car is started, in order to insure that the water will be properly mixed with the solution. Otherwise, there will be possibility of a layer of pure water remaining on top of the solution, to ultimately freeze if the temperature is low enough. Care should be taken not to add more liquid than required, as much damage may be done through corrosion of terminals and mounting.

Conclusion

The example of the many troubles that we have all experienced in driving motor cars in cold weather, should have impressed us most forcibly with the need for more care, judgment and attention in connection with the five prime factors of automobile operation, as discussed above. On them hinge the motorists' personal comfort, safety and peace of mind throughout the winter months. The automobile is just as sensitive to cold as a human being,—more so in fact, because it can not help itself in an extremity. We bundle our own precious bodies in fur and woolens, wear rubbers, and drink hot coffee, etc. to counteract the cold. On the other hand, perhaps our car stands at the curb with but a robe over the radiator. When it does not start as readily as in July, the average human will blame the rotten gasoline or oil he thinks he has been sold, whereas he himself is alone at fault. Study and application of the conditions, factors and recommendations discussed herein would render his car a new creation in his hands, and give him an engine capable of starting at the first throw of the starter.

True, there are difficult conditions to be met with in many climates, but they can all be very nearly counteracted with common sense, volatile gasoline, proper lubricants, the right cooling mixture, and observation of the two vital points:

1. Never to flood or prime the carburetor to excess, and

2. Never to start with the throttle wide open

Exhaust Gas Poisoning

SOME comment has been occasioned by the article on Exhaust Gas Poisoning which appeared in the June, 1922, issue of LUBRICATION, especially in regard to the matter of headache as an indication of possible poisoning from carbon monoxide. Investigation of this condition* indicates that some people do not develop headache even when exposed to low concentrations for several hours, and yet they may exhibit severe and even disastrous symptoms otherwise. Again, if the concentration of carbon monoxide in the air is sufficiently high, a headache may not develop for sometime after returning to fresh air, or the subject may become unconscious almost without warning, resulting perhaps in death.

In other words, while the symptom of headache is the most common indication of carbon monoxide poisoning, the time of its appearance, or whether it appears at all, will depend upon the concentration of carbon monoxide in the air and upon individual peculiarities.

The statement in the previous article on Exhaust Gas Poisoning in regard to there being apparently no danger from carbon monoxide poisoning if headache is taken as a warning and the patient immediately returns to fresh air should therefore not be taken too literally as it may not hold in all cases. In the opinion of authorities there might be possibility of an accident or even disastrous results if headache alone were taken as the primary symptom. Persistent yawning, sleepiness, dizziness, and lassitude are frequent symptoms. Many subjects have a feeling that the skin is stretched tightly across the forehead. There is no symptom specifically characteristic of carbon monoxide poisoning but when any of the above symptoms occur it is an indication that there is something abnormal either in the condition of the man himself or in the air he is breathing. If not sure of the purity of the air, the man should go to a point where it is unquestionably

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